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RESEARCH AND DEVELOPMENT IN JAPAN: 1989 UPDATE

Summary

From an overall standpoint Japan's research and development efforts show great stability. Despite slow economic growth in the 1986-87 period induced by the yen's rapid appreciation against the dollar, aggregate Japanese R&D outlays have climbed. Private-sector R&D continues to dominate overall research outlays, indicating that Japan's research efforts are heavily application-oriented. At the same time, subtle changes are taking place in the composition of Japanese R&D. Restrictive government budgets have forced changes in public-sector R&D priorities. In the private sector the expansion of basic research is increasingly necessary. Finally, numerous domestic and foreign factors are challenging Japan's current approach to research and development.

Overview

Although the latest overall statistics on Japan's R&D spending are complete only through the year ending March 31, 1988, points of interest still can be derived from the data. It should be kept in mind, however, that the data (especially from private firms) are developed through a voluntary survey by the Science and Technology Agency and may not be entirely complete or accurate.

Growth - One immediately obvious point is that the growth of overall R&D spending sagged sharply in FY 1986 and FY 1987 (see Table 1), falling to one-third to one-half the rates of the FY 1983-FY 1985 period. The decline is easily traced to a falloff in business outlays. Rather than leading the R&D expansion as they had in the 1970s and the first half of the 1980s, companies trailed the pack, with spending growth lower than that of total R&D spending. This is true for both the data reflecting which organization performed the work (Table 1a) and the listing of sources of funds (Table 1b). Despite consistent

Table 1: Japan's R&D Expenditures, FY 1982-FY 1987

(in billions of yen and percent)

a. By Organization

Fiscal Year	Companies	Research Institutions	Universities	Total
1982	Y4,039.0	Y949.3	Y1,540.4	Y6,528.7
Change	11.3%	4.7%	6.6%	9.1%
Share	61.9%	14.5%	23.6%	100.0%
1983	4,560.1	971.0	1,649.6	7,180.8
Change	12.9%	2.3%	7.1%	10.0%
Share	63.5%	13.5%	23.0%	100.0%
1984	5,136.6	1,033.1	1,724.2	7,893.9
Change	12.6%	6.4%	4.5%	9.9%
Share	65.1%	13.1%	21.8%	100.0%
1985	5,939.9	1,160.6	1,789.8	8,890.3
Change	15.6%	12.3%	3.8%	12.6%
Share	66.8%	13.1%	20.1%	100.0%
1986	6,120.2	1,240.2	1,832.6	9,192.9
Change	3.0%	6.9%	2.4%	3.4%
Share	66.6%	13.5%	19.9%	100.0%
1987	6,494.3	1,384.5	1,957.9	9,836.6
Change	6.1%	11.6%	6.8%	7.0%
Share	66.0%	14.1%	19.9%	100.0%

b. By Source

Fiscal Year	Government	Private	Foreign	Total
1982	Y1,666.2	Y4,855.5	Y7.0	Y6,528.7
Change	3.3%	11.3%	14.8%	9.1%
Share	25.5%	74.4%	0.1%	100.0%
1983	1,721.4	5,451.1	8.2	7,180.8
Change	3.3%	12.3%	17.1%	10.0%
Share	24.0%	75.9%	0.1%	100.0%
1984	1,777.8	6,108.6	7.6	7,893.9
Change	3.2%	12.1%	-7.3%	9.9%
Share	22.5%	77.4%	0.1%	100.0%
1985	1,867.3	7,014.9	8.1	8,890.3
Change	5.0%	14.8%	6.6%	12.6%
Share	21.0%	78.9%	0.1%	100.0%
1986	1,955.3	7,229.7	7.9	9,192.9
Change	4.7%	3.1%	-2.5%	3.4%
Share	21.5%	78.4%	0.1%	100.0%
1987	2,111.8	7,716.6	8.2	9,836.6
Change	8.0%	6.7%	3.8%	7.0%
Share	21.5%	78.4%	0.1%	100.0%

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

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Japanese corporate rhetoric that R&D is akin to a sacred cow, the data show that Japanese firms put restraints on research budgets as part of their efforts to adjust to the rapid appreciation of the yen against other major currencies. It is important to note, however, that while growth slowed it did not stop.

As for government R&D funding and expenditures by universities and research institutions, the patterns are less evident. Restrained by an austere fiscal policy, the growth of government R&D funds lagged well behind the overall pace from between FY 1983 and FY 1985 (Table 1b). In the last two accounting years, however, the government has been more generous, showing the largest percentage gains of the three sources. It appears that research institutions gained favor in the mid-1980s as an outlet for R&D expenditures (Table 1a), showing growth rates in the latter years well above the overall figures.

Distribution - Despite data showing dwindling growth rates, the Japanese private sector still is the dominant actor in Japanese R&D activities, providing 78.4 percent and spending 66 percent of all research monies. Not surprisingly, this results in a strong commercial bias in Japanese research programs -- one factor behind Japan's high international competitiveness in a broad number of industries. According to STA, 86.6 percent of Japan's total R&D spending in FY 1987 was devoted to application or developmental purposes (see Table 2).

Table 2: Japan's Research Expenditures by Purpose, FY 1982-FY 1987

(in billions of yen and percentage share)

Fiscal Year	Basic Research	Applied Research	Developmental Research
1982	Y815.7	Y1,498.9	Y3,480.5
	14.1%	25.9%	60.1%
1983	896.7	1,630.1	3,882.8
	14.0%	25.4%	60.6%
1984	959.9	1,780.8	4,340.2
	13.6%	25.1%	61.3%
1985	1,030.6	2,001.8	4,985.9
	12.9%	25.0%	62.2%
1986	1,102.8	2,030.8	5,185.0
	13.3%	24.4%	62.3%
1987	1,250.2	2,166.8	5,497.3
	14.0%	24.3%	62.3%

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

The role of foreigners in Japan's R&D environment remains small. Moreover, foreign R&D funds have not grown in step with domestic monies. In fact, the level of spending at the end of FY 1987 had just managed to equal FY 1983's mark. The yen's appreciation possibly accounted for part of the stagnation, but lack of foreign interest in Japanese R&D probably is the major reason. Only since 1988 have greater numbers of foreign firms actively begun to establish R&D facilities in Japan -- moves that will not show up in STA's reports until 1990 at the earliest.

Government Spending

Tokyo's role in Japanese R&D continues to be controversial. While the government's absolute R&D spending forms a minority of total outlays, some foreign observers argue that government programs provide strong guidance to the private sector as to what areas of research to stress. Others counter that Tokyo's role has been less of a factor than the strong competitive dynamic that has driven Japanese firms to become world-class competitors in a broad range of industries. The truth, as usual, lies somewhere in between. In certain industries, such as semiconductors, government R&D programs have helped raise the level of the domestic industry's technology. In other industries, such as motor vehicles, Tokyo has had almost no hand in technological advancement. The debate over Tokyo's R&D role will be explored in greater depth later in this report, but first, a review of the hard figures is in order.

Outlays for research and development gradually are taking a bigger piece of the budget pie. Although R&D expenditures as a percentage of total general account expenditures appear stable, their share of discretionary spending generally has crept upward since FY 1982 (see Table 3). The austere fiscal policy

Table 3: Japanese Government Research Expenditures as a Share of the General Account Budget, FY 1982-FY 1989

(revised budgets in billions of yen and percent)

a. As a Share of Total Expenditures

Fiscal Year	Total Expenditures	Research Expenditures	Share
1982	Y47,562.1	Y1,448.0	3.0%
1983	50,839.4	1,448.9	2.8
1984	51,513.4	1,477.6	2.9
1985	53,222.9	1,521.6	2.9
1986	53,824.8	1,599.0	2.9
1987	58,241.2	1,655.0	2.8
1988	61,851.7	1,715.7	2.8
1989*	60,414.2	1,814.8	3.0

b. As a Share of Discretionary Expenditures

Fiscal Year	Total Expenditures	Research Expenditures	Share
1982	Y33,120.0	Y1,448.0	4.4%
1983	35,356.8	1,448.9	4.1
1984	33,244.5	1,477.6	4.4
1985	33,352.3	1,521.6	4.6
1986	33,425.7	1,599.0	4.8
1987	35,276.5	1,655.0	4.7
1988	37,308.5	1,715.7	4.6
1989*	35,380.5	1,814.8	5.1

*Initial budget.

Source: Ministry of Finance

adopted during Prime Minister Yasuhiro Nakasone's tenure affected even this area, which is viewed as a top national priority. The apparent easing of fiscal restraint in the current fiscal year is clear from the sharp jump in R&D's share of discretionary outlays. One year's figures, however, do not constitute a trend. With concern over the government's long-term fiscal health still strong, a return to a tight budget policy is a distinct possibility.

An interesting trend in government spending is visible, particularly at the first level of disaggregation. STA breaks total R&D spending into three

Table 4: Japanese Government R&D Expenditures, FY 1988

(in millions of yen and percentage change)

	Science Promotion	Energy Research	Other Research	Special Research	Total
Diet	Y517	YO	YO	YO	Y517
	-1.4%	--	--	--	-1.4%
Japan Technology Council	0	0	903	0	903
	--	--	5.5%	--	5.5%
Police Agency	972	0	0	0	972
	5.1%	--	--	--	5.1%
Hokkaido Development Agency	143	0	0	0	143
	0.1%	--	--	--	0.1%
Defense Agency	0	0	82,700	0	82,700
	--	--	11.6%	--	11.6%
Economic Planning Agency	716	0	0	0	716
	0.9%	--	--	--	0.9%
Science and Technology Agency	170,978	159,766	9,667	90,545	430,955
	6.4%	-2.6%	-49.7%	7.2%	1.3%
Environment Agency	7,752	0	0	0	7,752
	-2.1%	--	--	--	-2.1%
Land Agency	105	0	0	0	105
	-34.1%	--	--	--	-34.1%
Justice Ministry	849	0	0	0	849
	5.4%	--	--	--	5.4%
Foreign Ministry	0	2,655	3,762	0	6,417
	--	4.9%	-0.1%	--	1.9%
Finance Ministry	337	0	0	641	978
	0.8%	--	--	-4.9%	-3.0%
Education Ministry	63,757	0	127,416	621,781	812,954
	6.7%	--	1.0%	4.6%	4.2%
Health Ministry	32,319	0	1,128	10,612	44,059
	8.1%	--	-7.9%	22.7%	10.8%
Agriculture Ministry	61,195	0	1,847	3,600	66,642
	0.2%	--	-0.2%	-5.3%	-0.2%
International Trade and Industry Ministry	54,652	2,260	11,471	152,843	221,226
	0.2%	-18.4%	-0.9%	0.2%	-0.1%
Transportation Ministry	12,461	0	1,250	916	14,627
	-2.3%	--	65.9%	-8.8%	0.8%
Posts and Telecommunications Ministry	4,169	0	110	26,000	30,279
	3.3%	--	2,123.0%	4.0%	4.3%
Labor Ministry	601	0	0.7	3,106	3,708
	-0.1%	--	0.0%	2.4%	2.0%
Construction Ministry	5,206	0	254	0	5,459
	1.1%	--	-28.9%	--	-0.8%
Home Affairs Ministry	543	0	0	0	543
	1.4%	--	--	--	1.4%
Total	417,272	164,680	240,509	884,044	1,706,504
	4.2%	-2.7%	4.7%	3.3%	3.1%

Source: Japan Society for the Promotion of Science, Japanese Scientific Monthly, June 1988.

broad categories: science and technology promotion, which includes the budgets of the numerous national research institutions, advisory bodies and promotional organizations; other research, which covers energy conservation work, educational support programs, international cooperation projects and small business programs; and special research, which provides for special university research, alternative energy development and goal-specific research. Over the past six fiscal years, the allotments among the three categories have tilted steadily toward special research at the expense of other research (see Tables 4 and 5). Because each category is so broad, however, it is difficult to derive anything meaningful from the shift.

Table 5: Japanese Government R&D Expenditures, Planned FY 1989

(in millions of yen and percentage change)

	Science Promotion	Energy and Other Research	Special Research	Total
Diet	Y533	Y0	Y0	Y533
	3.0%	--	--	3.0%
Japan Technology Council	0	867	0	867
	--	-4.0%	--	-4.0%
Police Agency	1,020	0	0	1,020
	4.9%	--	--	4.9%
Hokkaido Development Agency	147	0	0	147
	3.1%	--	--	3.1%
Defense Agency	0	93,068	0	93,068
	--	12.5%	--	12.5%
Economic Planning Agency	764	0	0	764
	6.7%	--	--	6.7%
Science and Technology Agency	189,400	166,043	111,181	466,623
	10.8%	-2.0%	11.4%	6.0%
Environment Agency	7,882	0	0	7,882
	1.7%	--	--	1.7%
Justice Ministry	871	0	0	871
	2.6%	--	--	2.6%
Foreign Ministry	0	6,408	0	6,408
	--	-0.1%	--	-0.1%
Finance Ministry	348	0	738	1,087
	3.3%	--	15.2%	11.1%
Education Ministry	68,439	128,366	657,517	854,322
	7.3%	0.7%	5.7%	5.1%
Health Ministry	36,371	1,161	10,838	48,370
	12.5%	2.9%	2.1%	9.8%
Agriculture Ministry	62,350	1,929	3,400	67,679
	1.9%	4.5%	-5.6%	1.6%
International Trade and Industry Ministry	55,799	13,628	164,213	233,640
	2.1%	-0.7%	7.4%	5.6%
Transportation Ministry	13,255	2,162	913	16,300
	6.4%	73.0%	-0.3%	11.4%
Posts and Telecommunications Ministry	4,341	105	26,000	30,447
	4.1%	-6.8%	0.0%	0.5%
Labor Ministry	612	1.0	3,945	4,557
	1.8%	0.0%	27.0%	22.9%
Construction Ministry	5,376	313	0	5,689
	3.3%	23.3%	--	4.2%
Home Affairs Ministry	555	0	0	555
	2.2%	--	--	2.2%
Total	448,032	414,049	952,745	1,814,827
	7.4%	2.2%	6.7%	5.8%

Source: Science and Technology Agency

A detailed examination of expenditure growth rates by field is more revealing (see Table 6). Most categories show no clear spending pattern. Space development and energy programs, both declared priorities, have undergone swings. The two items with the clearest trends are defense research and large-scale industrial technology programs. The Japan Defense Agency's allocation has enjoyed growth rates well above both total R&D spending and total general account budget growth. Clearly Tokyo's commitment to greater defense spending includes defense-related R&D. Just as evident is Tokyo's move away from its support of large-scale industrial technology, which has been devoted to basic industries such as shipbuilding and steelmaking.

Table 6: Growth of Japanese Government Research Expenditures by Selected Field, FY 1983-FY 1988

(in percent)

Fiscal Year	Space Development	Energy Programs	Japan Defense Agency	Large-Scale Industrial Technology
1983	3.6%	-2.8%	8.1%	-7.9%
1984	-0.2	-5.5	13.6	-16.2
1985	2.4	6.6	31.5	-16.9
1986	0.8	0.6	12.7	-31.9
1987	3.1	-2.5	12.1	-15.2
1988	-5.4	-2.7	11.6	-48.4

Source: Science and Technology Agency and Japan Society for the Promotion of Science

A perusal of spending on selected R&D programs by agency supports these general observations and reveals still other details (see Table 7). Perhaps the most surprising feature is the cutback of most nuclear energy-related programs. With many of Japan's experimental nuclear reactors nearing activation, cuts in the budgets of the Japan Nuclear Development Research Institute and the Japan Reactor Development Center are curious. While figures on government research outlays are interesting, keep in mind that the ministries and agencies account for less than one-third of all Japanese R&D; industry is where much of the research, particularly that with commercial consequences, is being done.

Private R&D

STA statistics indicate that individual industries responded differently to the volatile economic conditions of FY 1986 and FY 1987 (see Table 8). Exchange rate shifts, commodity price swings and corporate rationalization programs inevitably affected R&D programs. While the average growth of corporate R&D was 12.6 percent in FY 1984 and 15.6 percent in FY 1985 (see JEI Report No. 43A, November 17, 1987), it was only 3 percent in FY 1986 and 6.1 percent in FY 1987. Certain industries slashed R&D budgets in response to tougher times: precision machinery makers cut their research outlays by 1.3 percent in FY 1986 in sharp contrast to the 20.5 percent expansion the previous period; expenditures by nonelectric machinery makers went from a 13.4 percent expansion in FY 1985 to a 0.9 percent contraction in FY 1986.

Table 7: Expenditures on Selected Science Programs by Agency, FY 1988-FY 1989

(in millions of yen)

	FY 1988	FY 1989
Japan Defense Agency		
Technology development	Y81,756	Y92,068
Science and Technology Agency		
Agency research (including four air and space development organizations)	28,473	31,753
Physical Chemistry Research Institute	16,034	16,056
New Technology Development Association	2,061	1,850
Science and technology promotion survey	5,561	6,944
Space Development Association	96,534	106,757
Ocean development research	9,472	10,675
Ocean Science and Technology Center	9,277	10,359
Japan Nuclear Development Research Institute	97,310	94,845
Japan Reactor Development Center	62,279	61,217
National Nuclear Research Laboratory	1,815	2,043
Research management costs	9,667	9,867
Environment Agency		
National Disaster Research Institute	4,022	4,134
National Water-borne Disease Center	418	421
National Disaster Prevention Institute	2,344	2,283
Disaster prevention survey	819	869
Foreign Ministry		
International Atomic Energy Commission	2,655	2,616
OECD Nuclear Power Committee	211	191
Finance Ministry		
Brewing Research Institute	337	348
Education Ministry		
Ministry research (including six education centers)	6,735	6,840
Research grants	48,880	52,600
Japan Technology Promotion Council grants	4,768	5,568
Health Ministry		
Agency research (including seven population research projects)	9,819	10,266
Research grants	15,455	17,825
Radiation effects research	2,061	2,249
Health science research	4,410	5,464
Cancer research projects	1,638	1,639
International cancer research	115	129
Medical and drug information system	223	212
Agriculture, Ministry		
Agency research laboratories (including 18 agricultural research centers)	44,939	45,458
Agricultural technology development	9,417	9,787
Large-scale projects	1,245	1,300
Biotechnology development	1,445	1,509
Research machinery and equipment	1,962	2,021
Agricultural technology promotion	2,139	2,203
Agricultural machinery research	815	844
Red tide research	222	288
Food product technology	529	518
International Trade and Industry Ministry		
Agency research (including 15 research centers)	25,841	26,343
Large-scale industrial technology projects	2,344	1,001
Computer industry promotion projects	3,800	3,722
Next-generation basic technology projects	2,980	1,188
New energy technology projects	1,589	1,201
Energy conservation projects	671	547
International aircraft development	4,417	4,190
Small business technology improvement	1,717	1,630
Transportation Ministry		
Agency research (including four ship technology centers)	7,153	7,369
Geostationary weather satellite management	2,251	2,251
Geostationary weather satellite launches	2,915	3,481
Magnetic levitation train technology	779	900
Posts and Telecommunications Ministry		
Electrotechnical laboratories	4,169	4,341
Construction Ministry		
Agency research (including one engineering center)	4,524	4,654

Source: Science and Technology Agency

Table 8: Japan's R&D Expenditures by Industry, FY 1986-FY 1987

(in billions of yen and percentage change)

	FY 1986		FY 1987	
	Total	Change	Total	Change
Agriculture	Y4.3	-3.2%	Y5.8	33.0%
Mining	21.7	-0.4	19.5	-9.8
Construction	121.1	9.3	128.3	5.9
Manufacturing	5,739.6	3.5	6,101.2	6.3
Food Products	147.2	10.3	179.1	21.7
Textiles	62.7	0.2	66.5	6.0
Pulp and Paper	33.9	4.7	33.5	-1.3
Publishing and Printing	16.4	-10.9	21.7	32.0
Chemicals	983.6	5.0	1,095.9	11.4
Industrial Chemicals and Synthetic Fibers	409.0	8.3	452.5	10.6
Oils and Paints	97.9	9.7	111.4	13.9
Pharmaceuticals	342.0	0.0	380.7	11.3
Other	134.8	5.7	151.2	12.2
Petroleum and Coal Products	68.6	0.5	70.2	2.3
Plastic Products	70.0	6.7	85.9	22.8
Rubber Products	80.2	0.5	85.2	6.2
Nonmetallic Mineral Products	187.6	7.7	177.9	-5.2
Steel	255.3	6.2	245.2	-4.0
Nonferrous Metals	110.2	9.6	104.4	-5.2
Fabricated Metal Products	94.7	-7.8	94.8	0.2
Nonelectric Machinery	379.1	-0.9	418.8	10.5
Electric Machinery	1,980.0	2.2	2,163.5	9.3
Communications and Electronics Equipment	1,360.4	2.9	1,497.8	10.1
Other	619.6	0.5	665.7	7.4
Transportation Equipment	989.8	5.8	969.6	-2.0
Motor Vehicles	840.4	5.4	814.8	-3.1
Other	149.4	7.9	154.8	3.7
Precision Machinery	199.2	-1.3	204.2	2.5
Other	81.2	14.9	84.9	4.6
Transportation, Communications and Utilities	233.5	-10.0	239.4	2.6
Total	6,120.2	3.0	6,494.3	6.1

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

By FY 1987, however, the recovery already was evident in some industries. Producers of communications and electronic equipment, for example, more than tripled the rate of research spending compared with the previous year. Particularly notable were the big increases in the agricultural sector, publishing and printing, the food products industry and the plastics industry. Equally interesting is the contraction of research outlays by the motor vehicle industry.

While the previous statistics appear to call into question the absolute devotion by Japanese firms to steady, long-term research and development spending, corporate R&D expenditures as a percentage of gross sales soundly support this contention (see Table 9). In FY 1984 the average ratio of R&D outlays to gross sales for Japanese industry was 1.99 percent; the comparable FY 1985 figure was 2.31. In FY 1986, when the business sector felt the brunt of the yen's appreciation, the R&D/sales ratio actually rose to 2.57 percent. By this criterion, the recovery of FY 1987 was less spectacular, with the industry average rising only 0.02 percentage point.

Table 9: Japan's Ratio of Corporate R&D Expenditures to Gross Sales by Industry, FY 1986-FY 1987

(in percent)

Industry	FY 1986	FY 1987
Agriculture	0.24%	0.31%
Mining	1.16	1.01
Construction	0.55	0.51
Manufacturing	3.03	3.14
Food Products	0.85	0.99
Textiles	1.23	1.42
Pulp and Paper	0.80	0.77
Publishing and Printing	0.64	0.80
Chemicals	4.31	4.53
Industrial Chemicals and Synthetic Fibers	3.56	3.76
Oils and Paints	3.42	3.85
Pharmaceuticals	6.89	6.96
Other	3.87	4.00
Petroleum and Coal Products	0.62	0.64
Plastic Products	2.09	2.16
Rubber Products	2.92	3.25
Nonmetallic Mineral Products	2.87	2.82
Steel	2.54	2.40
Nonferrous Metals	2.11	1.90
Fabricated Metal Products	1.22	1.50
Nonelectric Machinery	2.77	2.99
Electric Machinery	5.50	5.61
Communications and Electronics Equipment	5.63	5.78
Other	5.23	5.26
Transportation Equipment	3.21	3.22
Motor Vehicles	3.20	3.17
Other	3.28	3.45
Precision Machinery	4.59	4.91
Other	1.07	1.12
Transportation, Communications and Utilities	0.96	0.84
All Industry Average	2.57	2.59

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

It is easy to judge the relative technology intensity of various Japanese industries from Table 9. Industries such as pharmaceuticals (6.96 percent), electric and electronic machinery (5.61 percent), precision machinery (4.91 percent) and chemicals (4.53 percent) unsurprisingly led the way in FY 1987. What is interesting is that a number of "mature" industries, such as steel, are not at the bottom of the ranking. Steelmakers, in particular, have tried to increase their research efforts in the past few years in their efforts to diversify and restructure.

The steady research efforts of Japanese industry have paid off handsomely in a broad range of industries. Outside observers, especially in the United States, are highly impressed with Japan's technology base (see JEI Report No. 12B, March 24, 1989), even if domestic scientists downplay their own technical prowess. Admiration overseas is so great that it has become tinged with a fear that Japan will dominate critical technologies within a few years. The developing world as well praises Japanese technological advances and hopes that Japan will provide not only increased monetary support for global development but a key to its treasure trove of technology as well. The latest statistics from STA show that while Japan is still a technology sponge, the balance between technology imports and exports is not as skewed as it once was.

Japan's Technology Trade

Just as with trade in goods, Japanese companies must report technology licensing contracts to the government. According to the latest STA figures, Japan continues to run a deficit with foreigners in terms of the overall number of contracts and their total value (see Tables 10 and 11). It is difficult to say that Japan's technology trade is moving toward balance. While the overall deficit fell to just Y3.9 billion ($27.9 million at Y140=$1.00) in FY 1984, it has swung back and forth since then, reaching Y79.3 billion ($566.4 million) in FY 1987. In terms of the number of contracts, however, Japan continues to narrow the deficit, from 3,145 cases in FY 1980 to 576 in FY 1987.

Of greater interest is the balance of new contracts made each year. In this respect Japan has been a net contributor of technology since a breakout was provided in FY 1975, both in terms of quantity and value. This trend ended in FY 1987, however, when the value of new technology imports surpassed that of exports by Y11.4 billion ($81.4 million). Given a history of wide swings in the number of cases and their value, it is unclear if this represents a new trend or simply an aberration.

A review of corporate technology trade by industry reveals centers of activity (see Table 12). Not surprisingly, manufacturing accounts for the vast bulk of all activity, with the chemical and the electric machinery industries at the forefront. Again indicating strenuous efforts to diversify, the steel industry is fourth in terms of activity. The electronics and the nonelectric machinery industries are primarily responsible for the jump in activity between FY 1986 and FY 1987, as the former saw both exports and imports fall and the latter experienced mixed results.

By region (see Table 13) Japan's corporate technology trade presents an unsurprising picture. The developing areas of the world are the recipient of the largest share of know-how exports, while North America and Europe provide nearly all of Japan's imports. It is interesting to note patterns of change,

Table 10: Japan's Technology Imports, FY 1950-FY 1987

(number of approved cases and value in billions of yen)

	Cases		Value	
	Total	Of Which New:	Total	Of Which New:
FY 1950-FY1955	1,148	n.a.	Y24.9	n.a.
FY 1960	588	n.a.	34.2	n.a.
FY 1965	958	n.a.	60.1	n.a.
FY 1970	1,768	n.a.	155.9	n.a.
FY 1975	6,766	796	169.1	Y13.3
FY 1976	6,050	632	177.3	17.9
FY 1977	6,659	685	190.1	16.9
FY 1978	6,573	936	192.1	38.2
FY 1979	7,012	1,020	241.0	26.8
FY 1980	7,248	919	239.5	27.7
FY 1981	7,207	844	259.6	24.9
FY 1982	6,936	929	282.6	44.4
FY 1983	7,839	1,073	279.3	42.4
FY 1984	7,316	982	281.4	31.8
FY 1985	7,679	1,245	293.2	33.3
FY 1986	8,635	1,141	294.2	33.6
FY 1987	8,186	813	339.4	56.2

Table 11: Japan's Technology Exports, FY 1950-FY 1987

(number of approved cases and value in billions of yen)

	Cases		Value	
	Total	Of Which New:	Total	Of Which New:
FY 1950-FY1955	n.a.	n.a.	Y0.3	n.a.
FY 1960	n.a.	n.a.	0.8	n.a.
FY 1965	n.a.	n.a.	6.1	n.a.
FY 1970	861	n.a.	21.2	n.a.
FY 1975	2,811	1,073	66.6	Y18.9
FY 1976	2,767	775	83.4	27.0
FY 1977	2,880	897	93.3	36.3
FY 1978	3,157	1,063	122.0	47.1
FY 1979	3,667	1,087	133.1	52.1
FY 1980	4,103	1,237	159.6	74.3
FY 1981	4,877	2,017	175.1	70.8
FY 1982	4,738	1,970	184.9	63.3
FY 1983	6,403	2,494	240.9	74.9
FY 1984	5,426	1,824	277.5	90.9
FY 1985	5,885	2,099	234.2	73.3
FY 1986	7,199	1,730	275.9	51.8
FY 1987	7,610	1,655	260.1	44.8

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

Table 12: Japan's Corporate Technology Trade by Industry, FY 1986-FY 1987

(number of cases and value in billions of yen)

	FY 1986				FY 1987			
	Exports		Imports		Exports		Imports	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Total	5,469	Y224.1	7,494	Y260.6	5,955	Y215.6	7,373	Y283.2
Agriculture	7	0.1	0	0.0	5	0.1	4	0.0
Mining	12	0.3	17	0.2	12	1.0	41	0.2
Construction	288	20.8	210	1.8	229	12.8	151	0.9
Manufacturing	5,136	193.5	7,261	258.4	5,681	200.8	7,155	281.0
Food Products	106	4.9	87	10.8	96	5.0	103	9.8
Textiles	182	4.6	123	3.2	228	4.4	123	3.7
Pulp and Paper	39	0.5	37	0.9	30	0.4	35	0.5
Publishing	24	0.2	43	0.3	15	0.1	52	0.6
Chemicals	941	38.2	955	40.6	1,161	39.3	898	40.6
Synthetic Fibers	411	15.3	437	14.9	497	18.9	439	14.9
Fertilizers	202	2.3	129	3.4	234	3.0	131	3.7
Pharmaceuticals	244	17.3	278	12.6	285	16.1	210	13.6
Other	84	3.4	111	9.6	145	1.3	118	8.4
Petroleum and Coal Products	9	0.1	88	3.1	11	0.3	97	3.5
Plastic Products	68	1.3	74	1.0	81	1.3	77	0.9
Rubber Products	69	2.2	101	5.4	72	3.1	92	3.3
Nonmetallic Mineral Products	204	5.5	144	6.6	210	6.2	158	6.6
Steel	461	21.5	301	5.8	373	10.0	410	8.0
Nonferrous Metals	162	3.6	183	4.2	173	2.6	201	10.7
Fabricated Metal Products	162	1.5	198	3.1	170	1.3	238	2.9
Nonelectric Machinery	420	6.8	1,064	25.4	665	8.7	998	21.3
Electric Machinery	1,366	53.0	2,505	91.3	1,415	61.1	2,422	109.5
Machine Tools	436	16.9	354	30.4	598	21.3	441	34.
Electronics	930	36.1	2,151	60.8	817	39.8	1,981	75.0
Transportation Equipment	727	43.8	963	49.0	688	49.2	876	48.8
Motor Vehicles	502	40.2	346	11.3	444	46.0	296	8.4
Other	225	3.6	617	37.8	244	3.2	580	40.4
Precision Machinery	88	1.9	238	4.2	124	2.9	249	6.7
Other	108	3.7	157	3.6	169	4.7	126	3.8
Transportation, Communications and Utilities	26	9.4	6	0.2	28	0.9	22	0.8

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

Table 13: Japan's Corporate Technology Trade by Country, FY 1984-FY 1987

(number of cases and value in billions of yen)

a. Exports

	FY 1984		FY 1985		FY 1986		FY 1987	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Asia	2,549	Y112.5	3,047	Y87.5	2,748	Y86.5	3,152	Y86.4
China	406	43.1	417	26.4	454	19.7	405	9.4
Taiwan	512	10.0	559	7.9	532	8.5	590	12.3
South Korea	598	14.9	798	18.2	732	21.1	816	27.5
Thailand	218	8.3	214	6.2	203	5.4	294	7.3
Philippines	111	0.6	320	4.4	89	0.6	133	2.0
Indonesia	228	13.6	174	5.2	196	4.4	182	3.2
Malaysia	119	5.0	320	4.4	128	3.2	147	3.1
West Asia	386	30.8	167	14.1	94	10.5	52	1.6
North America	944	71.9	1,058	58.7	1,006	62.3	1,058	72.5
United States	751	65.9	896	51.8	869	57.7	912	65.9
South America	199	3.7	243	8.7	216	5.2	198	4.5
Brazil	107	1.9	133	3.3	127	3.8	107	2.5
Europe	993	40.7	1,072	45.5	1,040	43.6	1,184	40.3
Great Britain	168	6.8	183	5.3	161	7.6	190	10.6
West Germany	217	4.7	253	11.3	247	7.8	297	7.4
France	141	4.6	129	4.8	145	5.9	162	5.2
Netherlands	38	2.1	41	4.8	41	2.5	53	2.1
Switzerland	42	4.9	44	3.3	53	3.8	52	2.3
Africa	222	12.8	135	6.6	189	9.5	147	5.0
Oceania	133	5.1	163	13.0	176	6.6	164	5.3
Australia	n.a.	n.a.	124	11.9	139	5.8	116	4.2

b. Imports

	FY 1984		FY 1985		FY 1986		FY 1987	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Asia	63	Y0.3	169	Y0.9	15	Y0.3	12	Y0.1
China	2	0.1	114	0.7	4	*	2	*
Taiwan	51	0.1		*	0	0.0	2	*
South Korea	8	0.1	52	0.0	4	*	4	*
West Asia	2	*	2	*	94	10.5	2	*
North America	4,437	194.0	4,814	210.3	4,926	174.6	4,747	179.3
United States	4,335	193.0	4,772	208.6	4,825	173.8	1,667	178.6
South America	26	0.0	1	*	4	*	3	*
Europe	2,750	86.7	2,664	81.6	2,516	85.1	2,568	103.4
West Germany	975	17.8	859	17.6	903	20.7	847	21.4
Great Britain	429	13.2	566	14.6	477	13.0	512	10.3
France	374	10.4	285	6.8	298	7.3	313	22.1
Switzerland	269	16.0	319	16.3	241	17.5	273	17.4
Netherlands	156	14.1	156	15.5	163	15.6	173	20.8
Africa	5	0.0	1	*	3	*	3	*
Oceania	33	0.3	28	0.3	28	0.4	38	0.3

*Less than Y50 million.

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

however. The number of technology export cases to the United States has grown significantly since FY 1984 even if the value has not. Exports to Europe, on the other hand, had retreated in FY 1987 from the high in FY 1985, actually falling below the FY 1984 level in value terms. The area of most activity is clearly Japanese exports to Asia, although even here the value lately has been stagnant. Exchanges with West Asia (a pseudonym for the Soviet Union and Eastern Europe) show a sharp decline in both quantity and value terms.

As for particular countries, it is clear that the transfer of Japanese technology to the rapidly developing economies of South Korea, Taiwan and Thailand is on the increase. Dealings with Africa and South America, in contrast, show either a decline or stagnation. There obviously is room for Japan to broaden the scope of its technology transfers. (For a related look at technology transfers, see JEI Report No. 22A, June 9, 1989.) The challenge of becoming a technology font for the world is only one of several facing Japan's research community.

Challenges Facing Japanese R&D

While Japan's R&D picture may be rosy at the moment, forces that could compel fundamental changes are building. As Japan has found in industrial and financial arenas, policies that have served the country so well in the postwar era may be out of step with current economic realities.

Basic versus applied technology - Japan has focused its energies since 1950 on catching up with technologically advanced countries with such success that it finds itself at the forefront of several fields. Policies, organizations and attitudes that helped Japan to find, adopt and improve foreign technology are not necessarily suited to developing new technology from scratch. Tokyo has been urging corporations to increase funding for basic research for several years, but the results have been modest. Referring back to Table 2, it is clear that the share of total R&D funds devoted to basic research has not changed significantly since FY 1982. Broken down by which organization performed the work, industry appears to be devoting a greater share of resources to basic research, if at a snail's pace (see Table 14). Tokyo is in no position to criticize the private sector on this account. While the government is sponsoring some highly acclaimed groundbreaking research -- such as the Exploratory Research for Advanced Technology (ERATO) program -- such projects are few and far between.

As is the case in the United States, universities are the center of basic research activities. Tokyo has been encouraging ties between private firms and universities for several years. Its latest effort is to encourage existing academic institutions around the country to specialize in a particular technology. Private firms interested in particular technologies then would be drawn to set up research facilities nearby, forming "research cores" all around Japan. The program relies heavily on universities to act as a source of innovative research, but the organization of university science departments is so rigid it often stifles creativity. Without educational reform, Japanese universities may not be able to meet the expected goals.

Equally fundamental is the difficulty of reorienting private R&D efforts toward basic research. Japanese management has a reputation for taking a long-term approach to business strategy, but the stagnant share of basic research

Table 14: Japan's Research Expenditures by Performance Organization by Purpose, FY 1983-FY 1987

(share of each organization's total expenditures in percent)

Fiscal Year	Basic Research	Applied Research	Developmental Research
1983			
Universities	57.4%	35.0%	7.6%
Research Institutions	13.2	33.2	53.6
Companies	5.2	21.8	73.0
1984			
Universities	54.9	36.9	8.3
Research Institutions	12.6	30.9	56.5
Companies	5.7	22.0	72.3
1985			
Universities	54.2	37.4	8.4
Research Institutions	12.3	30.0	57.7
Companies	5.9	21.9	72.1
1986			
Universities	54.2	37.4	8.4
Research Institutions	13.8	27.4	58.8
Companies	6.1	21.6	72.3
1987			
Universities	54.2	37.4	8.4
Research Institutions	15.8	26.0	58.2
Companies	6.6	24.7	71.7

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

reveals their true attitude toward this field. Tokyo, however, has yet to roll out the heavy guns, such as tax incentives, in this campaign. Nevertheless, it is clear that Japan will remain dependent on access to the vast amount of basic research performed in the United States and Europe for some years to come. This "free ride" on U.S. government-supported basic R&D has generated another challenge facing Japan's R&D establishment.

Technonationalism - For decades the United States has welcomed foreign students to its universities both to learn and to contribute to the world's storehouse of scientific knowledge. As U.S. dominance has been challenged over a broad range of important commercial sectors, such as consumer electronics, integrated circuits, high technology materials and computers, there has been a growing chorus of complaints that Washington's support for basic R&D primarily is helping U.S. competitors. The United States is concerned particularly that losing its technology lead will have severe consequences for its ability to defend its own and the free world's security. The result of these fears is growing support for technological nationalism (see JEI Report No. 24A, June 24, 1988).

It is easily arguable that Japan has practiced technonationalism for many years: government-funded programs were open only to domestic firms;

government-held patents could be licensed only to domestic companies; few provisions were made for supporting foreign researchers in Japanese universities and research institutions; and the results of Japanese research were not widely available to foreigners (mainly due to a lack of translation capacity). When Japan was perceived abroad as having little to offer technologically, these policies were not an issue. Now that Japan is a technological power, however, these policies have become sources of friction.

To neutralize the trend toward technonationalism in the United States and Europe, Tokyo has been trying to open its R&D establishment as much as possible. Foreign firms are courted actively to join government research projects. A handful of foreign firms have access to government patents. And the number of articles and presentations submitted by Japanese researchers to international journals and meetings is growing quickly. Tokyo and the United States have signed two major technology exchange agreements (one dealing with military technology, the other with general technology) and have inaugurated the Joint High-Level Committee on Science and Technology to smooth out frictions. Tokyo also is trying to integrate its R&D programs with the global research community. This solution to technonationalism, however, presents a significant challenge in and of itself.

Internationalization of Japanese R&D - Tokyo has embarked on a program to internationalize its R&D efforts. This, however, is easier said than done. A case in point is former Prime Minister Nakasone's 1986 announcement of an international program to explore basic human biochemistry. The Human Frontiers program was seen as a 20-year project with up to half of the projected Y1 trillion ($7.1 billion) cost paid by Tokyo. Foreign researchers not only would receive funds and participate in research but would codirect various parts of the program as well. However, until the FY 1989 budget, which allocates Y2.3 billion ($16.4 million) for this purpose, funding has been practically nonexistent. What funds have been appropriated have gone for planning and consultations. The delay has created foreign skepticism about Tokyo's sincerity.

Tokyo has pushed harder, however, to open its national laboratories to foreign researchers. STA announced that it could support as many as 100 foreign researchers in FY 1988. Fewer than 20 Americans applied. The main obstacles usually cited are Japan's high cost of living and the language barrier. American scientists who have gone to Japan, however, say that adjusting to both problems was far easier than they had expected. And, once in Japan, they found the experience very rewarding.

Tokyo also is taking steps on this side of the Pacific to encourage more Americans to take advantage of Japan's research. The National Science Foundation received nearly $5 million from Tokyo to bolster its program to send Americans to Japanese laboratories. Programs such as the Massachusetts Institute of Technology's MIT/Japan Science and Technology Program, which provides Japanese language training and positions in Japanese corporate facilities to American researchers, are lauded by both Tokyo and the private sector.

Japanese corporations also are trying to help. Hitachi, Ltd. initiated a Research Visit program in 1984 to invite foreign researchers to work for a year in its central research laboratory in Tokyo. Hitachi reports that interest in its program is strong, with over 70 applications for 30 positions in FY 1989. Hitachi will accept 35 of the applicants, following a practice of

allowing more than the announced number to participate. Such programs, however, still are rare in Japan. And it is access to private Japanese research that most interests the United States.

Economic restructuring - This is a long-term challenge to Japan's high technology machine. While both the government and private industry continually stress the need for the country to maintain a strong manufacturing sector as the backbone of the economy, the greatest growth and innovation is taking place in the service sector. If the manufacturing sector's relative share of the economy continues to shrink, the demand for engineers and scientists also could fall off.

The service sector is likely to draw an ever greater share of the cream of Japan's workforce simply because wages often are higher and prospects for advancement better. Several Japanese publications claim that a majority of engineering and science graduates from Japan's top universities no longer enter the manufacturing sector. They are drawn instead to the high salaries offered by banks and securities companies. As the percentage of Japan's population under 30 years old shrinks in the coming decades, it is unclear if there will be sufficient human resources to keep Japan's R&D machine humming.

For the time being, however, Japan is moving rapidly to a top position in the global technology race. Flush with cash from the economic recovery, Japanese firms and the government will pour ever greater funds and human resources into developing basic as well as applied science.

For further information, contact Jon Choy.

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The views expressed in this report are those of the author and do not necessarily represent those of the Japan Economic Institute.